

Chaos, Criticality, and Strategic Thought

*Steven R. Mann
April 1991
National War College*

Submitted under the direction of Clifford R. Krieger, COL USAF.

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE APR 1991		2. REPORT TYPE N/A		3. DATES COVERED -	
4. TITLE AND SUBTITLE Chaos, Criticality, and Strategic Thought				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) National Defense University National War College Fort McNair Washington, DC 20319				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release, distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT UU	18. NUMBER OF PAGES 28	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

A revolution of unprecedented scale is taking place that will transform strategic thought in ways yet unimagined. The bittersweet truth is that this has little to do with the "new world order" set to follow the end of the Cold War and the success of Desert Storm. The true revolution in progress is a scientific one, and its effects will change the pattern both of warfare and of strategic thought. Yet our attention is fixed on this year's international reshuffling. Absorbed by the transitory, we ignore the epochal.

Scientific advances are pushing us beyond our reductionistic Newtonian concepts and into the exotica of chaos theory and self-organized criticality. These novel lines of scientific inquiry have emerged only in the past three decades; in brief, they postulate that structure and stability lie buried within apparently random, nonlinear processes. Since past scientific revolutions have so transformed conflict, it is essential for US strategists to understand the changes in progress. One reason why this is important is technological: new principles yield new classes of weapons, just as basic quantum theory and special relativity ushered in nuclear devices.

A second and more fundamental motivation for understanding scientific change is the fact that our view of reality rests on scientific paradigms. The world appears to us as an intricate, disordered place, and we search for frameworks that will make sense of it all. These frameworks derive overwhelmingly from the physical sciences. Scientific advances, therefore, offer us new

ways of understanding a given environment, and can suggest innovative solutions to policy dilemmas. But despite the strategic community's hunger to grasp the technological benefits of change, it has been unable to adapt the advances to strategic thought.¹ To redress the imbalance, this paper will touch only lightly on the "hardware" benefits of scientific change and will focus instead on the conceptual aspects.

The strategic community's resistance to new paradigms is a tribute to the power of the current framework. The specific paradigm that permeates contemporary Western thought is best described as the Newtonian worldview. This paradigm is deterministic, linear, concerned with the predictable interaction of objects and forces, and oriented toward sequential change. This single worldview has powerfully influenced all areas of human inquiry. One commentator succinctly observes: "The other sciences accepted the mechanistic and reductionistic views of classical physics as the correct description of reality and modeled their theories accordingly. Whenever psychologists, sociologists, or economists wanted to be scientific, they naturally turned toward the basic concepts of Newtonian physics."² As one of the social sciences, military science rests upon these same assumptions. Precisely speaking, however, it is

¹"Strategic community" denotes that irregular web of academics, consultants, and servants of the taxpayer which suggests governmental responses to problems of tactical, operational, and national strategy, and thus defines our strategic culture.

²Fritjof Capra, *The Turning Point* (Toronto: Bantam Books, 1983), p. 47

the specific discipline of **mechanics** -- the science of motion and the action of forces on bodies -- which has captured our imaginations.

Why does the worldview of mechanics have such a hold on strategic thought? Part of the answer lies in the fact that military and political science truly developed as sciences in the eighteenth and nineteenth centuries, coincident with the rise of classical physics and mathematics. Einstein describes the spirit of the age:

The great achievements of mechanics in all its branches, its striking success in the development of astronomy, the application of its ideas to problems apparently different and non-mathematical in character, all these things contributed to the belief that it is possible to describe all natural phenomena in terms of simple forces between unalterable objects.³ [emphasis added]

There are, however, more tangible reasons. In the simplest sense, combat is mechanics. No surprise then that military strategy rests on a reductionistic, mechanistic framework. Since national strategy often borrows the metaphors of combat -- peace "offensives," the Cold "War" -- it is again no surprise that national strategy reflects the same bias. Politics is a continuation of war by linguistic means.

A second reason for the longstanding influence of mechanics is its accessibility. Before this century, physics (and its offshoot discipline, chemistry) had made relatively greater

³ Albert Einstein and Leopold Infeld, *The Evolution of Physics* (New York: Simon and Schuster, 1942), pp. 57-58

strides than other branches of science. Biological sciences were in their infancy until the latter part of the 1800s, and the advances which would challenge the structure of Newtonian physics were still in the future. In the previous century, mechanics was predominant.

Finally, this mechanistic worldview is reassuring, since it postulates a world of sequential change. It promises strategists that the course of events can be predicted if the underlying principles have been discovered and if the few variables involved are known. Unsurprisingly, therefore, modern theorists of war drew heavily and subconsciously on this mechanistic paradigm. On the level of military strategy, consider Clausewitz: the language of On War betrays the mechanistic underpinning: friction, mass, centers of gravity. Or Jomini, with his stress on the geometry of combat. On the level of national security strategy, note DOD's 1991 National Security Planning Guidance: "The demise of the Cold War can be likened to a monumental shift in the tectonic plates, unleashing a host of forces that are irrevocably reshaping the strategic landscape."⁴

Once this mechanistic world-view gained currency, it never lost its grip. This stasis is the unrecognized core of so many of our strategic dilemmas. The essential conservatism of the

⁴ US Department of Defense, *1991 National Security Planning Guidance* (DOD: Washington, DC, 1991), p. 1. This time-honored metaphor traces back at least to Joseph Nye's use in the 1970s.

national security establishment,⁵ combined with the understandable need for caution on central issues of war and peace, has discouraged theoretical innovation. The revolution in strategy founded on a mechanistic ordering of reality has been frozen in place, and the provocative doctrines of the last century have become the confining dogmas of this one.

Is there a problem? Conventional wars have validated much of Clausewitz, Liddell Hart, and others of that genealogy. The so-called revolutions in warfare before 1945 have represented only changes on the mechanistic margin. Motorized warfare, for example, increases the options of an attacking force but is still amenable to Clausewitzian analysis. Air power shifts the battle to a true third dimension, but does not invalidate the paradigm. So too, the increased destructiveness and accuracy of munitions leave war explicable within the classical framework. On the national strategic level, we still find it useful to examine the "strategic balance" between East and West, and to maintain and reform alliances that have their analogues in alignments of centuries past.

But we can only draw uneasy comfort from this. Within each honest strategist there is an impertinent voice whispering that life seldom stays true to predictions. The gap between theory and reality exists on the levels of both military and national strategy. Militarily, a number of weapons and modes of warfare

⁵ See among others Morris Janowitz, *The Professional Soldier* (New York: The Free Press, 1971), pp. 22-37.

have been developed in the past century which fit poorly within classical strategy. New weapons are comparatively easy to develop but difficult to place within a doctrinal framework. Biological agents and nuclear weapons are two of the tough cases. Indeed, the process of battle itself is disordered. Army doctrine predicts: "The high- and mid-intensity battlefields are likely to be chaotic, intense, and highly destructive... operations will rarely maintain a linear character."⁶

On a grand scale, the increasing complexity of foreign affairs cuts against the comfortable assumptions of classical strategy. Can we indeed describe our exquisitely variable international environment in traditional terms of "balance of power," polarity, or a shift of tectonic plates? The mechanistic worldview is good but not good enough. The daily headlines bring inconvenient reminders of how oversimplified these models are.

Not only does classical strategic thought seek to explain conflict in linear, sequential terms, but it compels us to reduce highly complex situations down to a few major variables. Traditionally, we see strategic thought as the interplay of a limited number of factors, principally military, economic, and political. More sophisticated discussions expand the set to include factors such as the environment, technological development, and social pressures. Yet even this list fails to

⁶ FM 100-5 (Washington, DC: Headquarters, Department of the Army, 5 May 1986), p. 2.

convey the full complexity of international affairs: what is the place of religion and ideology; where do nonnational actors such as terrorist movements fit; what of supranational actors such as global corporations; what of the role that personalities and institutions play? Moreover, as global communication increases, economic interdependence progresses, and democracy spreads, the number of policy influences grows exponentially. The accelerating pace of decisionmaking adds to the complexity. The closer we come to an honest appreciation of the international environment, the more we must confess that it is nonlinear and frustratingly interactive. This complicates analysis tremendously: "nonlinearity means that the act of playing the game has a way of changing the rules."⁷

Our daily experience as policymakers validates this. We bruise against reminders of imperfection and randomness every day. The classical worldview calls this "friction" and shunts it aside as a complication of the well-laid plans of policymakers.⁸ On reflection, though, it becomes clear that "friction" is the rule in life, not the exception. To keep our strategic paradigms workable, we have taught ourselves to ignore this. Yet

⁷Gleick, James, *Chaos* (New York: Penguin Books, 1987), p. 24.

⁸See "Oils for the Friction of War," in Westenhoff, Charles M. (ed.), *Military Air Power* (Maxwell AFB, Alabama: Air University Press, 1990), pp. 77-79. This section of the book is filled with quotations which track precisely with chaos theory. Indeed, one statement (Eilenberger, cited on p. 16) is sourced to a physicist researching nonlinear dynamics. The compilers perfectly identify the omnipresence of chaos and nonlinearity in war; all they lack is the vocabulary.

life is too complex to be described or explained by the interaction of a few simple variables.

We need to change our way of thinking about strategy. At first glance, this appears to be unrealistically ambitious. Strategic thought of the past few centuries does not appear to allow much room for innovation. As we have shown, however, our strategic frameworks are based on the mechanistic assumptions of classical physics. If we start with different assumptions, by incorporating different scientific paradigms, we may see more productive strategic principles emerge. A shift of framework is not a panacea -- war and diplomacy will remain as demanding and dangerous as ever -- but if we wish to pull ourselves out of the current tired centrist muddle,⁹ we must recognize the assumptions that permeate our strategic culture and open ourselves to new frameworks.¹⁰

The Discipline of Chaos

⁹Stansfield Turner notes this and poses the question of "why there have been so few prominent strategic thinkers and writers in the past 50 years." Turner, "The Formulation of Military Strategy," in George E. Thibault (ed.), *The Art and Practice of Military Strategy*, (Washington, DC: National Defense University Press), 1984, p.15.

¹⁰This paper confines itself to chaos theory as a new basis for strategic thought, yet other sciences may offer equally innovative paradigms for the strategist. A strategic framework based on principles of the life sciences will go much further than our mechanistic paradigm to illuminate the "biological warfares" of BW, guerrilla war, and terrorism. Similarly, use of quantum principles instead of a Newtonian conceptual framework will bring new insight to nuclear discussions. (And will also explain the curious phenomenon of nuclear physicists, not military professionals, taking a leading role in nuclear strategy. The physicists' familiarity with quantum principles makes them more adept at understanding the peculiar demands and potential of these decidedly non-Newtonian weapons.)

There is a revolution waiting to be claimed within the context of chaos theory. This new science lies on the uneasy border between mathematics and physics, and is defined by certain key principles:

- Chaos theory applies to dynamical¹¹ systems -- systems with very large numbers of shifting component parts;
- within these systems, **nonperiodic** order exists. Seemingly random collections of data can yield orderly yet nonrecurrent patterns;
- such "chaotic" systems exhibit sensitive dependence upon initial conditions. A slight change in any one of the initial inputs leads to disproportionately divergent outcomes.
- the fact that order exists suggests that patterns can be predicted in at least weakly chaotic systems.

The earth in revolution around the sun is nonchaotic. A slight change in orbital speed would only yield a slight change in its path of revolution. In contrast, a column of smoke rising into the atmosphere is chaotic. It rises straight up for a time, then suddenly breaks into a turbulent medley of whorls, twists, and zigzags. These loops seem to follow no particular order, yet mathematical modeling discloses regular patterns¹² when tracked. A slight change in velocity of the smokestream will form a completely different grouping of whorls and streams -- yet this second smokestream will also yield mathematically regular patterns.

¹¹"Dynamical," not "dynamic," is the preferred term among researchers. I follow the convention.

¹²The patterns exhibit period-doubling and have analogues in fractal geometry. See Gleick, pp. 121-137, 202-207.

"Chaos" is an unfortunate shorthand for this discipline. The word carries associations of formlessness and pure randomness that complicate the conceptual task. "Nonlinear dynamics" is a less loaded, more descriptive term, but chaos is the widespread scientific label, so chaos it will be in this paper.

The chaos paradigm does not contradict the classical paradigm -- chaos theory stems from classical physics and Cartesian mathematics -- but it transcends it. The classical framework describes linear behavior of individual objects; chaos theory describes statistical trends of very many interacting objects.

What are the implications of this science for the strategist? It is important for two reasons, one tangible -- technological innovations which exploit chaos theory will change the "hardware" of war -- and one theoretical: it offers fresh insights as a new foundation of strategic thought.

In "hardware" terms, chaos theory will have pathbreaking effects on military affairs through changes in the way we use technology now, as well as through development of new types of weapons. Information theory, artificial intelligence, and the military technologies based on these sciences will be transformed. One researcher postulates that chaotic changeability "is the very property that makes perception possible."¹³ At the very least, robotics will see major strides,

¹³Walter J. Freeman, "The Physiology of Perception," *Scientific American*, February 1991, pp. 78-85.

and we may be much closer to the day when armed robots will participate in combat. The list of applications has no limit: epidemiologic spread, meteorology, frequency-agile radar, aeronautic design, and cryptology come easily to mind. Nuclear targeting may become more accurate, given chaos theory's ability to model fluid turbulence. Post-nuclear ecology is a topic also well adapted to nonlinear analysis, and future discussions of nuclear winter will have to encompass chaotic principles. Cryptology is an especially tantalizing case, since chaos theory poses the possibility that what we believe to be random may not always be truly random.

Technology aside, chaos theory has certain other battle-related applications. Researchers have sought for decades to make sense out of the many factors which comprise the chaos of battle. One scholar, Trevor Dupuy, has developed an elephantine mathematical model which attempts to analyze battles through the interplay of several dozen variables. This Quantified Judgment Analysis Model is "a method of comparing the relative combat effectiveness of two opposing forces in historical combat, by determining the influence of environmental and operational variables upon the force strengths of the two opponents."¹⁴ Although the focus of the model is historical, Dupuy suggests that it may be predictive. If so, the implications are tantalizing: commanders will be able to quantify their chances

¹⁴Trevor Dupuy, *Numbers, Predictions, and War* (Indianapolis: Bobbs-Merrill, 1979), p. 50.

of battlefield success and systematically identify areas of weakness. Leaving aside the problem of subjectivity, the basic flaw is that the model is linear, yet the process of battle itself is tremendously nonlinear and irregular. Chaos theory may uniquely be able to take Dupuy's concept to its ambitious end.

On a theoretical level, we see a dismaying number of Ph.D.s attempting to understand patterns of wars in history. In 1972, J. David Singer and associates claimed to find regularity in peaks of global violence over a 150-year period -- "a rather strong periodicity emerges, with the dominant peaks about 20 years apart" -- as well as a peak in war beginnings in April and October.¹⁵ The goal of this research was to use the periodicity as a clue to factors which give rise to the violence. Other authors have linked patterns of conflict with "long cycles of world leadership" (Modelske), polarity-stability models (Waltz), and with the Kondratieff wave cycle of economic prosperity and depression (numerous authors).¹⁶ As with the Dupuy model, chaos theory may be the tool that transforms these subjective undertakings from a parlor game to a predictive model. Chaos researchers have already found unexpected identical patterns in social phenomena as disparate as cotton price levels and US national income distribution. This attribute of **universality** --

¹⁵J. David Singer and Melvin Small, *The Wages of War 1816-1965: A Statistical Handbook* (New York: John Wiley and Sons, 1972), p. 215, p. 375.

¹⁶See William R. Thompson, *On Global War* (Columbia, SC: University of South Carolina Press, 1988).

the principle that different nonlinear systems have inherently identical structures -- is a central principle of chaos theory.¹⁷

There remains much research to be done on the applicability of chaos theory to operational and tactical analysis. On the one hand, the process of battle is universally acknowledged as disordered, and thus amenable to nonlinear analysis.¹⁸ On the other hand, combat involves only a small number of actors as we define them, generally one force versus a second; thus theater-level combat falls outside of chaos theory, which describes the behavior of very large numbers of actors. Moreover, commanders expend tremendous effort in making armed forces act and interact in linear, mechanistic, predictable ways. Devices such as rank hierarchies, military discipline, unit structure, and warrior tradition serve to impose order and overcome random behavior. This further limits the dynamism of the system and suggests that chaos theory may have only limited applicability on the level of military strategy. Is battle truly chaotic or not? There are two useful answers to the question. One is to view the process of battle as fundamentally chaotic, but moderated to an orderly system with varying degrees of success as described above. A second possibility is to consider the process of battle as fundamentally linear and nonchaotic, and assert that it is our

¹⁷Gleick, pp. 83-87.

¹⁸A perhaps-apocryphal quotation, ascribed to "a German general officer" makes this point: "The reason that the American Army does so well in wartime is that war is chaos, and the American Army practices chaos on a daily basis." Cite unknown, suggestions welcomed.

individual **perceptions** of battle which are disorderly. In any case, these questions will bear more inquiry.

The Critical Threshold

The true value of chaos theory is to be found on a higher plane, in the domain of national strategy. Chaos should change the way we view the full set of human interactions, of which war is only one special part. The international environment is an exquisite example of a chaotic system. An intriguing offshoot of chaos theory -- "self-organized criticality" -- is perfectly matched to such an analysis. Bak and Chen define self-organized criticality:

Large interactive systems perpetually organize themselves to a critical state in which a minor event starts a chain reaction that can lead to a catastrophe...Although composite systems produce more minor events than catastrophes, chain reactions of all sizes are an integral part of the dynamics...Furthermore, composite systems never reach equilibrium but instead evolve from one metastable state to the next.¹⁹

IBM researchers are examining this theory using sandpiles: grains of sand are added one by one to a pile until a critical state is reached in which the next grain of sand added produces an avalanche. After that catastrophic reordering, the system is relatively stable as it builds toward the next reordering.

Interestingly, a number of metaphors already exist in political science which hint at criticality. The picture of international crises as a "tinderbox" is the most well-known one.

¹⁹Per Bak and Kan Chen, "Self-Organized Criticality," *Scientific American*, January 1991, p. 46. Metastable = relative, not absolute, stability.

In one respect, this metaphor remains particularly accurate: the development and spread of a forest fire is a useful example of a chaotic system and has been modeled by Bak, Chen, and Tang.²⁰ The tinderbox idea, however -- an explosive object waiting for a match -- falls short in conveying the dynamical nature of world affairs. A newer metaphor is the concept of "ripeness," as described by Haass and others. This view of international negotiation holds that some disputes are insoluble for a variety of reasons until the time arrives when they are "ripe." The key to successful negotiation, therefore, is exploiting this critical state.²¹

What framework better describes the reordering that is now taking place in the world than self-organized criticality? The "plate tectonics" metaphor, based on the classical framework, falls short. It postulates basic stability, broken by realignment of a few major forces. The full complexity of the situation is left to the imagination, if any, of the reader. As another example, examine the Soviet Union in the respective lights of the mechanistic framework and criticality theory. The classical framework encourages us to think in simple terms of a clash of forces: populists, Gorbachevian reformers, and conservatives. Self-organized criticality leads us to see a tremendous multiplicity of actors in a critical state that will

²⁰Bak and Chen, p. 53.

²¹See Richard N. Haass, *Conflicts Unending* (New Haven: Yale University Press, 1990).

inevitably progress to a metastable one after a catastrophic reordering.

The former model leads us to overestimate our influence on events and discount the ability of all but the major players to have a decisive impact on events. The paradigms of chaos and criticality, in contrast, highlight the disproportionate effects seemingly minor actors can provoke. The German physicist Gerd Eilenberger remarks:

The tiniest deviations at the beginning of a motion can lead to huge differences at later times -- in other words, minuscule causes can produce enormous effects after a certain time interval. Of course we know from everyday life that this is occasionally the case; the investigation of dynamical systems has shown us that this is typical of natural processes.²²

Chaos theory further notes that these deviations are self-organized; that is, they are generated by the dynamical system itself. Even absent external shocks, a sufficiently complex system contains the factors that will propel the system across the boundary of stability and into turbulence and reordering.

Now a troubling question arises: is chaos theory merely a useful metaphor to describe these interactions, or do these interactions actually follow the occult laws of chaos? This metaphysical puzzler is beyond the scope of this modest paper; but intuition, the conscience of the intellect, suggests that the second explanation is correct.

The originators of the concept indeed foresee application in

²²Westenhoff, p. 78.

security affairs: "Throughout history, wars and peaceful interactions might have left the world in a critical state in which conflicts and social unrest spread like avalanches."²³ Consider the example encountered earlier: the end of the Cold War as a shift of plate tectonics. Which framework gives a more accurate basis for strategy? The mechanistic framework seems to say that the plates have now shifted and we are in an indefinite period of stability upon which we can now rebuild a uniquely new world order. Criticality describes a dynamical process, merely metastable, which is even now building toward the next set of catastrophic reorderings.

The mechanistic view is too arbitrary and simple for international affairs. We must have as our starting point the fact that disorder, proceeding to reordering, is an inherent, inescapable feature of complex, interactive systems. We are deluding ourselves if we choose metaphors which suggest that externally imposed long-term stability can be a defining feature of the world. The world is destined to be chaotic because the multiplicity of human policy actors in the dynamical system have such widely variant goals and values.

The mechanistic paradigm encourages us to seek the causes of major change in external factors. It postulates basic inertia in a system, unless acted upon by some outside force. Criticality, in contrast, is self-organizing. The system proceeds to major change as a result of a small, almost negligible event. World

²³Bak and Chen, p. 53.

War I is an outstanding example of self-organized criticality. The killing of an archduke in an obscure Balkan town triggered a worldwide catastrophe that led to the deaths of 15 million and whose effects are felt even today.

Lebanon may be an example of perpetual criticality. The sad history, explosive geography, lack of cohesion and wildly high antagonisms of the actors give little hope for stability and predictability. Working within the classical strategic framework, however, the United States entered the fray in 1982 and emplaced Marines to bring balance to the situation and separate opposing forces. As one Marine officer remarked: "we walked a razor's edge."²⁴ The basic assumption was that the United States could be a neutral, stabilizing force. A system in criticality, however, offers no neutral ground. Once in it, you are of it, as we learned after catastrophe.

Reordering Strategic Thought

Amid the disorder, we are not bereft of strategy. Criticality theory is not a limitation for the strategist but a promising framework which helps explicate the fascinating disorder of the world. Once we arrive at an accurate description of our environment, we are in a position to create strategies which advance our interests. To create these strategies, we must begin with an examination of the factors which shape criticality. Some possibilities:

²⁴Colonel T.J. Geraghty, in Daniel P. Bolger, *Americans at War 1975-1986, An Era of Violent Peace* (Novato, CA: The Presidio Press, 1988), p. 210.

- o the initial shape of the metastable system;
- o the underlying structure of the metastable system;
- o cohesion among the actors; and
- o individual "conflict energy" of the actors.

Taking these factors one by one:

Initial shape simply means that the initial contours of a system influence the system's later development: the post-catastrophic outcome forms the base of subsequent actions. In our sandpile, the post-avalanche slopes and hills influence the shape of the new cone to be formed; in foreign affairs, the changed boundaries after World War II could not help but shape the subsequent course of events.

In sandpile terms, the grains fall onto a flat, circular surface: this is the **underlying structure**. The contours of this basic structure help determine the shape of the developing sandpile. In the international sense, underlying structure can be factors such as environment and geography. Kuwait's proximity to Iraq is a fundamental fact that shapes all subsequent policy in that area. Water supply is an example of an environmental underlying factor.

Cohesion determines the rate at which reordering takes place. Wet sand has different dynamics than dry sand. So too do ideologically and ethnically homogeneous systems have different dynamics than multiethnic or ideologically conflictive societies. On a military level, deterrence and arms control serve to increase cohesion. (N.B. Increased cohesion does not prevent criticality; it only means that the progression to criticality is slowed.)

Finally, I suggest that each actor in politically critical systems possesses **conflict energy**: an autonomous measure of energy which contributes to formation of the critical state. In our international system, this energy derives from the motivations, values, and capabilities of the specific actors, whether governments, political or religious movements, or individuals.

Chaos theory dictates that it is very difficult to make long-range predictions. The difficulty increases with the number of actors in the system and the duration of forecast desired. As a starting point, therefore, we should be suspicious of long-term strategic outlooks. This is a hard addiction to abandon. We clutch to the belief that there are maps that will take us through the dark woods of international affairs. But perhaps a different metaphor will help: we should instead seek to create lanterns to light our way along a path that shifts with the pace and direction of our stride.

Is this argument not contradicted by the success of containment, the ne plus ultra of long term strategic thinking? This policy, with its prescription for "unalterable counterforce at every point where they show signs of encroaching," is the full flowering of the mechanistic worldview in national security affairs.²⁵ Conventional wisdom, with the collapse of the Soviet

²⁵The plan of containment was implemented far more rigidly than its architect intended. Kennan, in retrospect, terms his 1947 article a call for ideological-political engagement, and suggests today that we need a containment theory "more closely linked to the totality of the problems of Western civilization." Chaos theory to

empire, says the policy of containment worked. But looking at the aggregate record, was it not this same policy that led us into Vietnam and into self-defeating support of authoritarian regimes from Iran to Nicaragua to the Philippines? Could we not have achieved a better end result with less cost if we had moved flexibly from island to island of order within the global sea of political chaos?

Now "beyond containment," we are debating the correct concept of polarity -- whether the world is multipolar, unipolar, polypolar, now that it is no longer bipolar. This debate is a another example of how we strive to unsee the obvious. Politically, the world has far too many and varied actors to be thought of in polar terms. Yet we seek to strip down complexity till we reach a scale we are accustomed to.

We are desperate in our desire for structure, thus the appeal of overblown new "orders," whether the New World Order, "strategic consensus," or the League of Nations. Will the New World Order mimic the mistakes of containment, forcing us to take unwise policy stands in pursuit of an illusory long-term stability? We may have already sacrificed more than we know in pursuit of this new stability: by conditioning Desert Storm on UN approval, we have constrained our future military options. Much of Congress, the American public, and the international community will expect a UN imprimatur as a legitimating

the rescue? See George F. Kennan, "Containment Then and Now," *Foreign Affairs*, Spring 1987.

prerequisite to future US use of force. And what have we actually gained in the desert? The attempt to create the New World Order through international legality has left Saddam Hussein firmly entrenched and ever defiant as the decimation of the Kurds proceeds.

Our desire for structure also helps explain the Western thirst for arms control. Even when the arms control regime is declaratory and has no military utility, as with the 1972 Biologic and Toxin Weapons Convention, we cling to the talismanic belief that the simple, declaratory existence of the treaty will help prevent the horrors it describes. Americans sanctify the arms control "process" as a good in itself, regardless of the strategic situation or the virtue of the treaties under negotiation.

Effective treaties and compacts can slow the progress of a system toward criticality, but we indulge in illusion if we believe absolute stability is attainable. In international affairs, all stability is metastability. The international environment is a dynamical system composed of actors -- nations, religions, political movements, ecologies -- which are in themselves dynamical systems. We should therefore be miserly when we incur immediate policy costs to achieve a future stability: odds are that we will not get what we bargained for. Stability is a consequence, not a goal. Indeed, "stability," like "presence," "nation-building," and even "peace," is a contextless goal. When such a goal is advanced as a policy

objective, it betrays either the inadequacy or the duplicity -- recall the Soviet "peace policy" -- of the underlying strategy.

How then to use criticality to our advantage? The true aim of national strategy is "shaping the sandpile," achieving the desired end state with the mildest upheaval. There are times when we will wish to delay formation of a critical state; there are times when we will wish to encourage it and will seek to shape the reordering. As all foreign policy operators know, shaping events is easier dreamed than done. There is not much we can do about initial shape or underlying structure. These are "givens" formed by history, geography, and environment. Our policy efforts must center on affecting cohesion and conflict energy. Internationally, items such as military alliances, and economic interrelationships (e.g. GATT), and agreed "rules of the road" build cohesion into the system. But the more promising, more neglected way to affect international change lies with the individual.

Conflict energy is at base a human property, since the individual is the basic building block of the global sandpile. Conflict energy reflects the goals, perceptions, and values of the individual actor -- in sum, the ideological "software" with which each of us is programmed. To change the conflict energy -- to lessen it or direct it in ways favorable to our national security goals -- we need to change the software. As hackers throughout the world know, the most aggressive way to alter software is with a "virus"; and what is ideology but another name

for a human software virus?

With this ideological virus as our weapon, let us move to the ultimate biological warfare and infect the target populations worldwide with the ideologies of democratic pluralism and respect for individual human rights. With a strong American commitment, enhanced by advances in communications and increasing ease of global travel, the virus will be self-replicating and will spread in delightfully chaotic ways. Our national security, therefore, will be best assured if we devote our efforts to winning the minds of countries and cultures that are at variance with ours. This is the sole way to build a world order that is lasting and globally beneficial. If we do not achieve this ideological change throughout the world, we will be left with only occasional periods of calm between catastrophic reorderings.

The tangible implication of this analysis is a sharp increase in support for USIA, National Endowment for Democracy, and for private sector exchange and educational programs. These programs lie at the heart of an aggressive national security strategy. Conversely, we need to react defensively as well. The true national security battleground is on the level of individual choice, and we are under attack by certain destructive strains, notably drug addiction. What is drug addiction but a destructive behavioral "virus," which spreads in epidemic fashion?

The Intuitive Core

The world is open to experience on many levels, and we would be acting unrealistically if we claimed primacy for any one

scientific paradigm over all of the others as a foundation of strategic thought. Each framework offers unique insights, and the art of strategy is choosing the most enlightening one for a given situation. Strategy has traditionally been described as the "iron linkage" of ends and means. The complexity of national security today suggests that such an Iron Age has passed, and we must develop a broader definition of strategy: not simply a match of means to ends but a match of paradigm to the particular strategic challenge. It makes little sense to define ends and select our means until we have achieved an accurate representation of the reality we encounter.

If we are open to a variety of scientific frameworks, we can generate more workable principles of strategy than we now possess. On an operational level, we can "remember" the principles of weapons still to be developed if we understand the theoretical principles which will give rise to those weapons. On a higher plane, we can understand the factors which dictate that a complex, dynamical system such as the USSR will change, and work more precisely to shape the transformation. We can learn to see chaos and reordering as opportunities, and not push for stability as an illusory end in itself. All of this awaits if we can transcend the bonds of the mechanistic framework, which dominates strategic thought.

We must, finally, recognize the limits of any framework, even the "counterframework" of chaos, and pay proper respect to the irrational, the intuitive. Strategic thought rests on

scientific paradigms, which in turn rest on mathematics, the language of science. The truths of mathematical systems, therefore, extend into our strategic concepts. One mathematical principle above all is important to us. Godel's Incompleteness Theorem states:

All consistent axiomatic formulations of number theory include undecidable propositions.²⁶

In our world there exists an infinite set of problems which have no logically consistent answer; there are some problems which any framework alone cannot solve. This theorem marks the limits of robotics in warfare, the limits of operations research, of all scientific inquiry, as applied to warfare, or indeed, to any discipline. We must accept the fact that warfare and strategy, like all undertakings which seek to describe and predict creative behavior, will contain unsolvable paradoxes. Nuclear deterrence may be an example of this. The poignant quotation from the time of Tet: "We had to destroy the village in order to save it"²⁷ may illustrate another.

Therefore, once you have achieved a strategic framework which is logically consistent and which provides a comprehensive, predictive description of war, you can no longer fully trust that framework. In plain talk from Colin Powell: "Never let adverse facts stand in the way of a good decision."

²⁶Paraphrased by Douglas R. Hofstadter, *Godel, Escher, Bach: An Eternal Golden Braid* (New York: Vintage Books, 1980), p. 17.

²⁷See Stanley Karnow, *Vietnam: A History* (New York: Viking Penguin, 1984), p. 534.

Any framework contains limitations which can only be transcended by the peculiar characteristics of human thought; what the physicist Roger Penrose refers to as "the instantaneous judgments of inspiration"²⁸ inseparable from human consciousness. What is that after all, but Clausewitz's coup d'oeil: those "glimmerings of the inner light which leads to truth."²⁹

Great strokes of strategy draw on this intuitive core. Yet strategists cannot live by inspiration alone. Inspiration unsupported by rigorous analysis becomes adventurism, thus intuitive gifts must be paired with an effective theoretical framework. Chaos theory is uniquely suited to provide one such framework, provoke us toward realistic policies in an incessantly changeable age, and inaugurate the long-overdue liberation of strategic thought.

²⁸Roger Penrose, *The Emperor's New Mind* (New York: Penguin Books, 1989), p. 422.

²⁹Carl von Clausewitz, *On War* (trans: Michael Howard and Peter Paret) (Princeton, NJ: Princeton University Press, 1984), Book One, Chapter 3, p. 102.